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Rearing Sockeye Salmon in Fresh Water

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(With one Figure.)

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REARING SOCKEYE SALMON IN FRESH WATER.

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In several instances, successful attempts have been made to rear the Atlantic salmon, *Salmo salar*, to maturity without permitting it to have access to the sea.

Yarrell[1] describes such an attempt that was made nearly a century ago as follows: "A large landed proprietor in Scotland . . . wrote as follows: 'In answer to your inquiry about salmon fry I have put into my newly formed ponds, the water was first let in about the latter end of 1830, and in April, 1831, I put in a dozen or two small salmon fry, 3 or 4 inches long, taken out of a river here, thinking it would be curious to see whether they would grow without the possibility of their getting to the sea or salt water. As the pond, between three and four acres in extent, had been newly stocked with trout, I did not allow any fishing till the summer of 1833, when we caught, with fly, several of those salmon, from two to three pounds' weight, perfectly well developed and filled up, of the best salmon colour outside, the flesh well-flavoured and well-coloured, though a little paler than that of new-run fish.'"

This attempt was successful as far as it went, but no evidence is given that any of the fish lived to maturity. It has been shown by Dahl, Hutton, and others that, in some rivers in particular, the Atlantic salmon commonly remains three years in fresh water, the length of time these were kept, without any artificial restraint. The experiment is interesting, however, since it shows that the retention idea is by no means of recent development.

Menzies[2] refers to this experiment and mentions others as follows:: "Since then various experiments in this direction have been conducted with more or less success, notably those by Sir J. Gibson Maitland, at Howietoun, where eggs deposited in the winter of 1880-1 were duly hatched and the fry reared until, when nearly four years old (i.e., the same age as grilse), they were found to be ready to spawn, and the ova of the females when fertilized by milt, were found to develop in a perfectly normal manner. In the report of the Fishery Board for Scotland for the year 1908, part II, app III, details are given of a male grilse kelt which, owing to an oversight, was kept for a year in a small fresh-water 'catch-pit,' and which, in spite of these unnatural conditions, had again become ripe for spawning.

"Through the kindness of Mr. George Muirhead, the commissioner for the Duke of Richmond and Gordon, who sent the scales and particulars to Mr. Calderwood, I have been able to examine the scales of a somewhat remarkable fish, which died at the Tugnet hatchery, on the Spey, in August last. The details of the life of this most interesting specimen—a male—as supplied by the keeper of the hatchery are as follows: 'Hatched in April, 1905, the parr was placed in the rearing pond in the summer of the same year, and was retained there until the date of its death in August, 1911, when it weighed 4 pounds 3 ounces. During this period it spawned twice, for the first time in January, 1910, and for the second and last time in March, 1911; on the latter occasion its weight was 5 pounds 3 ounces, 1 pound more than when it died.'

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[1] Yarrell, Wm. A history of British fishes, Part II, 1836, p. 21.

[2] Menzies, W. J. M. The infrequency of spawning in the salmon. Salmon Fisheries I, for 1911, Fishery Board for Scotland, 1912, p. 5.

"It is interesting to observe that, although this fish enjoyed steady land feeding, it had only attained one-tenth of the weight it would, in all probability, have reached had it spent the last four years of its life in the natural manner in the sea, and the scales shew that the feeding has been, as one might expect, of a regular character, and it would be impossible to estimate the age in the regular way. The absence of a spawning mark is at first sight particularly striking, although this is not so surprising when one remembers that a great deal of the erosion of scales takes place after the fish has ceased feeding and left the sea, and while it is in the river before spawning."

Masterman[3] makes reference to salmon that were bred in tanks at the Plymouth Marine laboratory. He says: "Through the courtesy of Dr. Allen, the Director of the Plymouth Marine laboratory, I was enabled to examine the scales of young salmon which were bred in the tanks, and for two successive seasons were 'stripped' of ripe ova and milt. Their scales show no trace of worn edge or of spawning mark." He gives a photograph of a scale of one of these salmon (see fig. 27).

Similar experiments have been carried on with the British "sea-trout", the migratory trout of the British coasts, the name applied to it by those who consider the "brown trout", said to be non-migratory, a different species and even by those who think the two are of the same species, developed under different conditions. Tate Regan[4] definitely states "In the British Isles there is only one species of trout." Lamond[5] gives an approving review of the arguments presented by Regan and in discussing one of these, viz., that sea trout, if prevented from going to the sea, will live and breed in fresh water, makes reference to an experiment carried out at Howietoun under the supervision of the hatchery superintendent, John Thompson, whose notes are recorded thus: "The parents were caught in a tributary of the river Forth, brought to Howietoun and spawned on November 23, 1886. There were 450 ova laid down to hatch of which some 350 hatched out successfully in February, 1887, and the fry (some 250) were shifted from the hatchery house to one of our ponds, in June of the same year and then fed the same as other fry. The young fish were again shifted into a larger pond in June, 1888, when the average size was found to be about three inches. In August, 1889, some specimen fish, about six inches in length, were taken from the pond by Dr. Day for examination and comparison with common trout, *S. fario*, and we were all agreed that it was impossible to distinguish them by the eye from *S. fario*. In April, 1890, the fish were again moved to another pond and I spawned some of the females in November of the same year, crossing the ova with milt from *S. levenensis* and *S. fontinalis*. A few fry of the former were hatched out and reared but were afterwards mixed with other fry. The remainder of the parent sea-trout were afterwards, I think, turned out into a reservoir, when about five years old. They never attained to any great size."

In all the cases mentioned, apparently the only difference observed between the fish retained in fresh water and those normally migrating is the difference in size, the retained specimens growing much more slowly than the normal migrating specimens. The scant supply of food in the fresh water as compared with the supply in the sea, which is commonly given as the reason for the slower growth in fresh water, apparently cannot be the controlling cause in all of these cases, since in some of them at least the fish may have been fed as much as they wished for. Possibly the lack of any necessity for special activity in search for food accounts for a similar lack of appetite and a sluggishness in digestion and a general condition that is not conductive to rapid growth. This would also account for any differences in external appearance and in the color of the flesh of the fish as well. The complete fresh water life, as far as these experiments show, causes no delay in the approach of the spawning period.

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[3] Masterman, A. T. Report on investigations upon the salmon with special reference to age determination by study of scales, Fishery Investigations, Board of Agriculture and Fisheries, series I, Vol. I, 1913, p. 31, London.

[4] Regan, C. Tate. The Fresh Water Fishes of the British Isles, 1911.

[5] Lamond, Henry. The Sea Trout, 1916.

In only one of these cases was the later life of the fish followed up and reported upon. This fish survived two spawning periods and lived to be 6½ years old. There is thus nothing to indicate that its life was shortened in the continued existence in fresh water, nor can it be said definitely that it was prolonged.

Regan contends that there is no structural difference between the sea trout and the brown trout, but the difference in general appearance is due to the length of time spent in fresh water. That is to say, he is of the opinion that the brown trout is simply a sea trout that has given up migrating to the sea. Lamond apparently is of much the same opinion. If this contention is correct, and it is backed up by many convincing arguments, the continued life in fresh water must have a physiological effect if not a morphological, different to that when migration to the sea takes place, because the brown trout is so different in general appearance, when grown, that it is usually considered a different species or it might even be said many different species, where local conditions produce an appearance, different from the typical.

An experiment with the sockeye salmon, *Oncorhynchus nerka*, which is being carried on at the hatchery at New Westminster, B.C., by Hatchery Officer H. W. Doak, under the jurisdiction of Lieut.-Col. F. H. Cunningham, Chief Inspector of Fisheries for British Columbia, may be of greater interest than any of these already it is of sufficient importance to be worth recording.

In the fall of 1912 some sockeye eggs were taken from Harrison lake to the Bon Accord hatchery, where they hatched out in the spring of 1913. The fry were put into rearing ponds near the hatchery, but later, when the hatchery was moved over to Queen's Park, New Westminster, on account of Canadian Northern Railway operations, the fish were removed to ponds on the new site, where some of them still live and thrive.

In the fall of 1915 some of the males, then in their third year, became ripe and the milt was removed. The spent fish mended perfectly and continued to live and grow. As none of the spawning fish were marked, it was not possible to tell if those spawned again in 1916, but certainly some of the males spawned in that year. None of the females showed any signs of developing a spawning condition in the third year, i.e., in 1915, but they did so the following year. When they were ripe the eggs were removed, artificially mixed with milt for fertilization, and put in the hatchery, but although they remained fresh for a long period none of them hatched out. The rest of the eggs were spawned naturally in the gravel at the bottom of the pond, but apparently they were not fertilized, as none of them hatched out either. The eggs were 5 to 5·5 mm. in diameter, somewhat smaller than even the smallest of normal sockeye eggs.

The spawning occurred about November 1, and on the 29th of January following a number of these fish were examined. There were nine of them altogether, running from 9 to 11 inches in length (not including caudal fin rays). They were not weighed, but probably none of them would weigh over a pound, and some of them not that much. The fish that had quit feeding during the spawning period, were taking food quite readily again and appeared to be perfectly mended. The skin was bright and metallic and the scales were shed quite readily.

Scales from four of them were taken for examination. Although there is much sameness in the rate of growth indicated throughout it is possible in almost every perfect scale to make out the winter check somewhat readily. The growth is not quite regular even during the active part of the year, the irregularity is most noticeable in the second year's growth, but it is probably on account of the general slow growth that it is more noticeable in these than in normal scales. There may have been some disturbing influences in connection with their life in ponds as small as those in which they were kept.

A calculation made to get the amount of growth each year gave the following results in inches):—

	Total length.	1st year.	2nd year.	3rd year.	4th year.
	11·0	2·3	3·5	3·0	2·2
	9·7	3·0	3·5	1·9	1·3
	9·5	2·8	3·0	2·1	1·6
	9·5	2·7	3·3	2·3	1·2
Average..	9·9	2·7	3·3	2·3	1·6

The first of these was a female, and probably all of the others were males. There is a marked difference in the growth in the third year, but it cannot be stated with certainty that the small growth in the last three but particularly in the second one was due to the spawning of these males in the third year. There was no indication of a spawning mark on any of the scales. (This agrees with Menzies' statement for the Atlantic salmon, quoted above).

The great majority of the Fraser river sockeye remain in the fresh water for one year. The average growth of 614 four-year-old sockeye, hatched out at the same time as these and caught in the summer of 1916, is as follows:—

Total length.	1st year.	2nd year.	3rd year.	4th year.
22·3	2·9	8·6	7·7	3·1

No sockeye belonging to the same year class but remaining two years in the fresh water have yet been obtained as these are usually caught when in the 5th or 6th year, but a comparison may be made with the 5-year fish that were hatched out the preceding year. The average of 56 of these is as follows:—

Total length.	1st year.	2nd year.	3rd year.	4th year.	5th year.
22·5	2·6	3·2	8·2	6·1	2·4

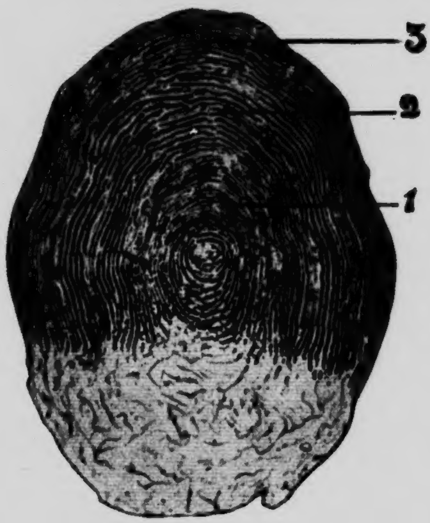
I have not seen any sockeye from the Fraser that had remained in fresh water for three years, and as far as I am aware, none have been reported. Dr. Gilbert has reported some from the Nass river, that remained in fresh water for three years, but has given no figure of the scales. Even if the growth rate had been calculated for these Nass river fish, no direct comparison could be made with the Fraser river fish.

As far as comparison can be made, these pond-reared fish have a growth parallel to that of other sockeye, that remain in the fresh water under normal conditions, but the comparison can be carried only to the end of the second year. There is nothing to indicate that hand feeding in the pond makes any improvement in growth over natural feeding in the streams or lakes. The growth in length in the third year is less than that in the second, and that in the fourth less than that in the third, a decrease in somewhat the same portion, although not to the same extent, as is found in those living in the sea.

There is nothing remarkable in the fact that these fish lived over the fourth winter. Five year specimens are found in all types of sockeye, six years specimens are comparatively common and seven year specimens have been reported. The outstanding feature of the whole question lies in the fact that these fish have spawned and have mended perfectly and some of the males have lived over a year after the first spawning.

A large number of sockeye, as well as all other species of Pacific salmon, certainly die soon after spawning, and there is no convincing evidence that any of them long survive the spawning process under normal conditions, but these pond reared sockeye survived and began feeding again, apparently little the worse. They were examined again on April 20 and the nine of them were still alive, of good colour, and apparently in good health. It is true that they did not go through a wearing struggle in getting to spawning beds but that cannot have made all the difference because many of the Pacific salmon, even in some cases the sockeye, spawn in streams that are reached from the sea with no special effort. The spawning effort itself should have been as severe on these as on those spawning under natural conditions or those artificially spawned. The physiological condition of the body must have become changed under the changed conditions of life, so that the fish has become, in its nature, more like a fish that normally remains in the fresh water throughout its existence. This may indicate that the genus *Oncorhynchus* is even more intimately related to the genus *Salmo* than has been suspected.

Mr. Doak has some pond-reared sockeye younger than these, and some coho at different stages as well, hence there is every chance for him to follow up the experiment far enough to get quite decided results.



EXPLANATION OF FIGURE.

The figure is from a photograph of a scale from a 4-year-old sockeye that was reared entirely in fresh water, taken from the fish on January 29. The numbers 1, 2 and 3, indicate the limit of the first, second and third year's growth, respectively. The margin is the limit of the fourth year's growth.